Explosion - Explosive Atmospheres Initial Approach

EU Directives → ATEX Directive

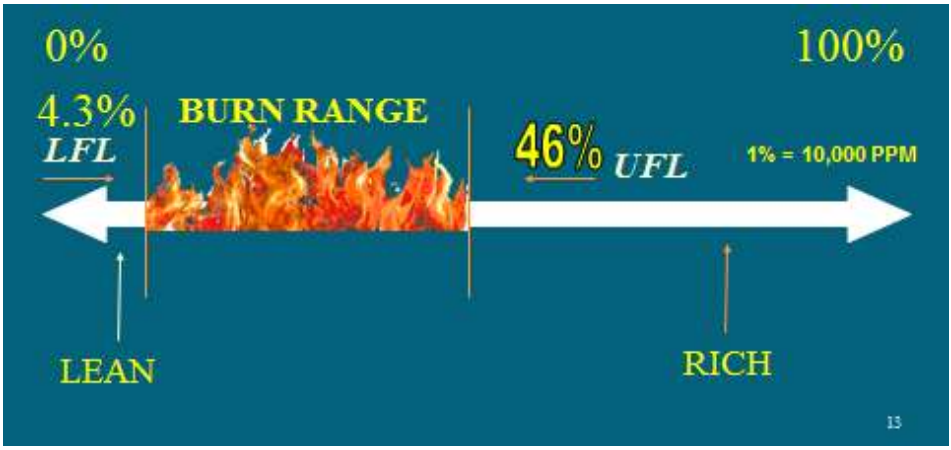
- 1999/92/ EC directed towards employers & employees
- 94/9/ EC directed towards suppliers of equipment

Definitions

- **Explosion –** rapid expansion of gases resulting in a rapid moving pressure or shock wave.
- **Confined explosion –** an explosion occurring within a vessel or a building. Usually results in injury to the building inhabitants and extensive damage.
- **Unconfined explosion –** an explosion occurring in the open. Usually results from spill of a flammable gas spill. These explosions are rarer than confined since dilution prevents explosions.
- **Dust Explosions –** an explosion resulting from the rapid combustion of fine solid particles. Many solid materials become very flammable when reduced to a fine powder.
- **Mechanical Explosion –** due to failure of vessel with high pressure non reactive gas.
- **Flash Point (FP)** – (a property of material used to determine the fire and explosive hazard; the lower the flash point, the easier it is to ignite the material) The lowest temperature of a liquid at which it gives off enough vapor to form an ignitable mixture with air.
- **Ignition Temperature (IT)** – The minimum temperature at which a substance will continue to burn without additional application of external heat.
- **Auto-ignition Temperature (AIT)** – The lowest temperature at which a combustible mixture will spontaneously ignite (without an ignition source but just from the energy of the environment).
- **Flammability Limits** – the range of compositions within which a mixture of air and vapor can produce a normal or explosive combustion if an ignition source is introduced.

- **Explosion Limits** – the range of compositions within which a mixture of air and vapor can produce an explosive combustion without any ignition source; these limits must be within the flammability limits.
- **Lower Explosive Limit (LEL)** – the minimum concentration (% in air) of a substance in air which is required for ignition. Concentrations below the LEL will not ignite. Below the LEL, the mixture is called "lean" (poor).
- **Upper Explosive Limit (UEL)** – the maximum concentration (% in air) of a substance in air which is required for ignition. Concentrations above the UEL will not ignite. Above the UEL, the mixture is called "rich".

Flammability Limits (H_2S)



- Lean mixture → not enough fuel to initiate combustion
- Rich mixture → not enough oxygen to sustain combustion

The Explosion Pentagon

Oxygen anyway exists in air (appr.21%)
Fuel must be flammable or explosive and be dispersed
Ignition is achieved when heat is generated at sufficient quantities or is concentrated

Dispersion contributes to rapid fire spreading
Confinement contributes in pressure rise

The **Explosion Pentagon** depicting the necessary simultaneous existence of the five parameters in order for a fuel to start burning, the combustion be sustained and an explosion to occur

Characteristics of a fire-related explosion

- Commonly begins with the ignition of a fuel that burns very rapidly (flammable liquid/ gas or fine combustible dust)
- Produces a large and sudden release of combustion gases
- Results in an adiabatic compression of the reaction (combustion) area that becomes very thin to form a combustion front
- The front travels at very high velocities towards the combustible mixture
- The front produces very high pressure differences
- In a confined (closed) space (e.g. a vessel) the volume of the combustion gases raise the space's internal pressure even if there is no adiabatic compression

Ignition Sources

- Table 6-3 gives the results of a study by Factory Mutual Engineering Corporation who studied over 25,000 industrial fires to determine the source of ignition.

TABLE 6-3 IGNITION SOURCES OF MAJOR FIRES[1]

Electrical (wiring of motors)	23%
Smoking	18%
Friction (bearings or broken parts)	10%
Overheated materials (abnormally high temperatures)	8%
Hot surfaces (heat from boilers, lamps, etc.)	7%
Burner flames (improper use of torches, etc.)	7%
Combustion sparks (sparks and embers)	5%
Spontaneous ignition (rubbish, etc.)	4%
Cutting and welding (sparks, arcs, heat, etc.)	4%
Exposure (fires jumping into new areas)	3%
Incendiarism (fires maliciously set)	3%
Mechanical sparks (grinders, crushers, etc.)	2%
Molten substances (hot spills)	2%
Chemical action (processes not in control)	1%
Static sparks (release of accumulated energy)	1%
Lightning (where lightning rods are not used)	1%
Miscellaneous	1%

[1] *Accident Prevention Manual for Industrial Operations* (Chicago: National Safety Council, 1974).